



Automated Identification of Initial Storm Electrification and End-of-Storm Electrification Using Electric Field Mill Sensors

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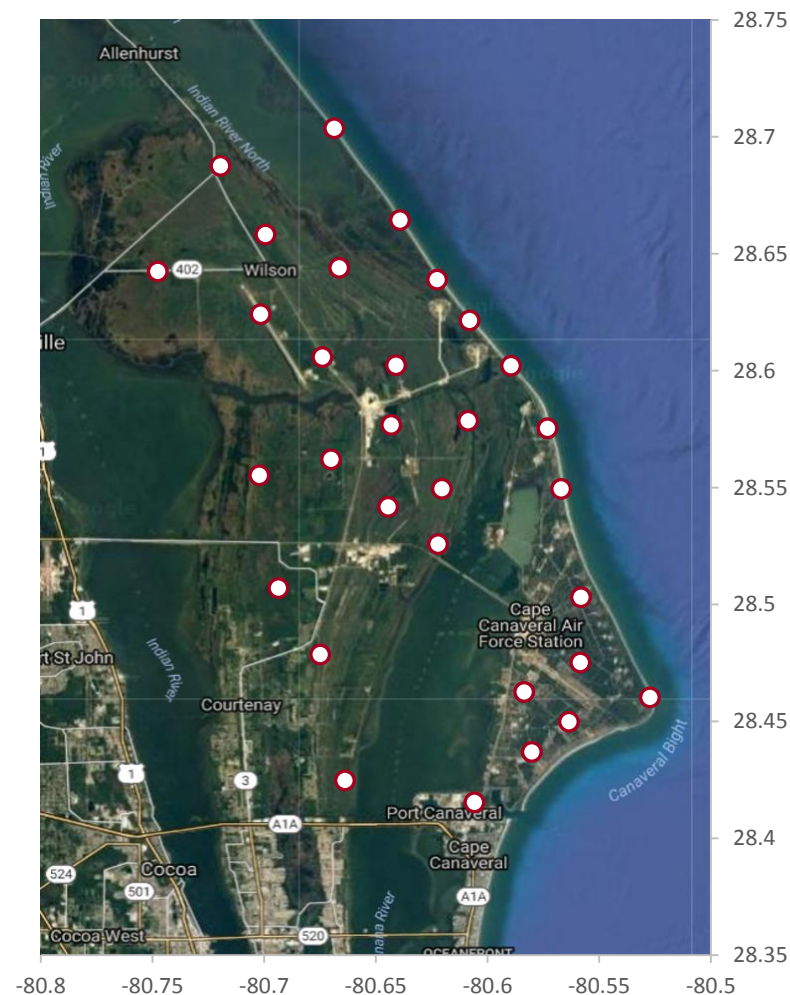
Background



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- The Eastern Range operates an Electric Field Mill Network of 31 sensors located over KSC and CCAFS
- The sensors were installed to identify electrified clouds and protect launch vehicles from triggered lightning.
- Electric fields can also be utilized to detect initial cloud electrification.

Electric Field Mill Locations





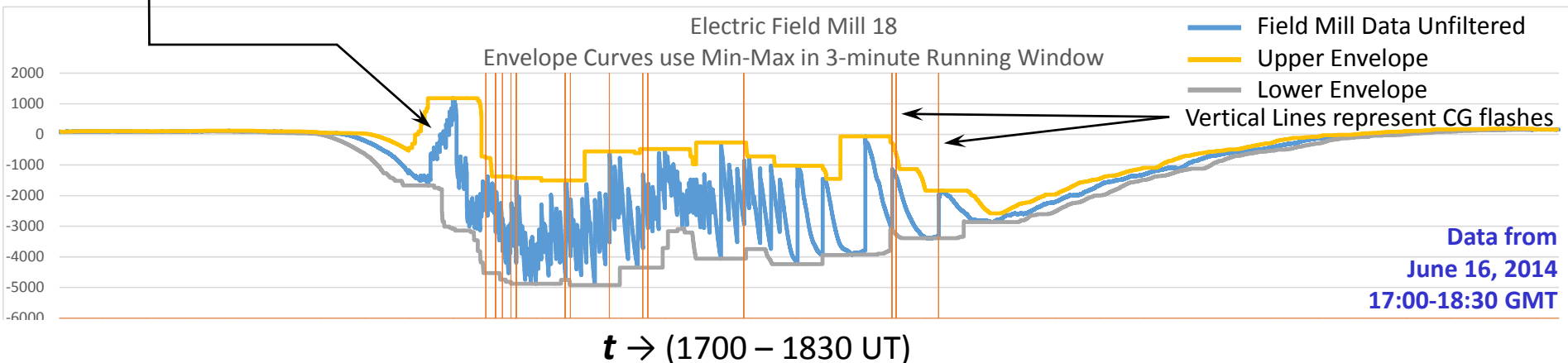
Purpose



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The difference between the maximum and the minimum envelopes of the electric field provides a measure of the agitation of the field. Additionally, the difference can be used in conjunction with average field to give a more complete characterization of the lightning hazard.

- For example, if agitation exceeds a threshold or the electric field value exceeds a threshold the threat of lightning is present. On the other hand, ***an average electric field can cancel out higher fields.***
- The envelope can be used to automate storm phase identification. For example, the difference between the minimum and maximum electric field envelopes is minimal prior to initial electrification.

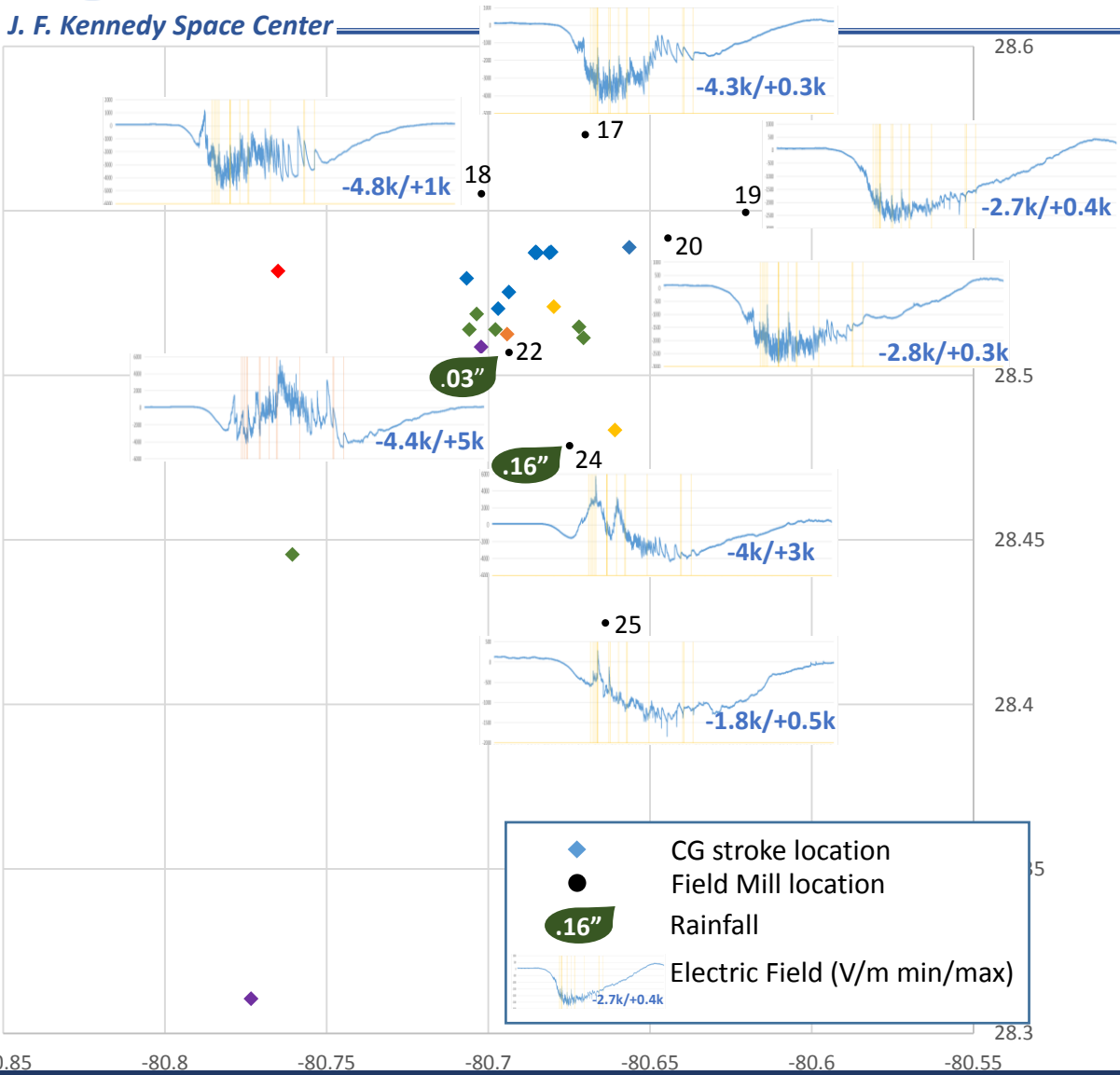




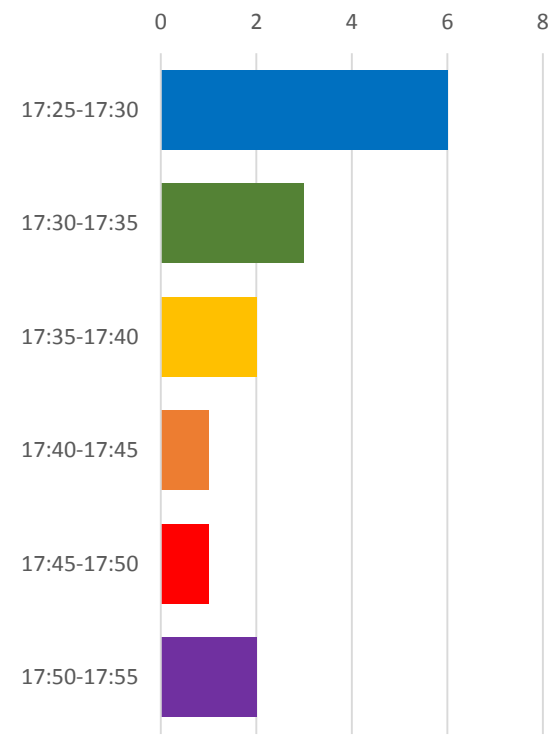
Depiction of Electric Field Variation for the Storm on 6/16/2014



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CG Flashes within 10 nmi Of Field Mill Network



Data from
June 16, 2014
17:00-18:30 GMT



Data Parameters



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FMs Data Validation

- Eliminated FMs with bad data such as flat-lined or empty files
- Did not use FM 31 (location on file was inaccurate)

Storm days:

- 6/12/2014
- 6/16/2014
- 7/6/2014
- 7/8/2014
- 7/15/2014

Success criteria

- Lead time is the elapsed time from the electric field envelope (3-min window) exceeding a specific threshold to the 1st CG flash within 5 nm of the field measurement
- Additional lead time prior to zero-crossing is desired with relatively few false alarms

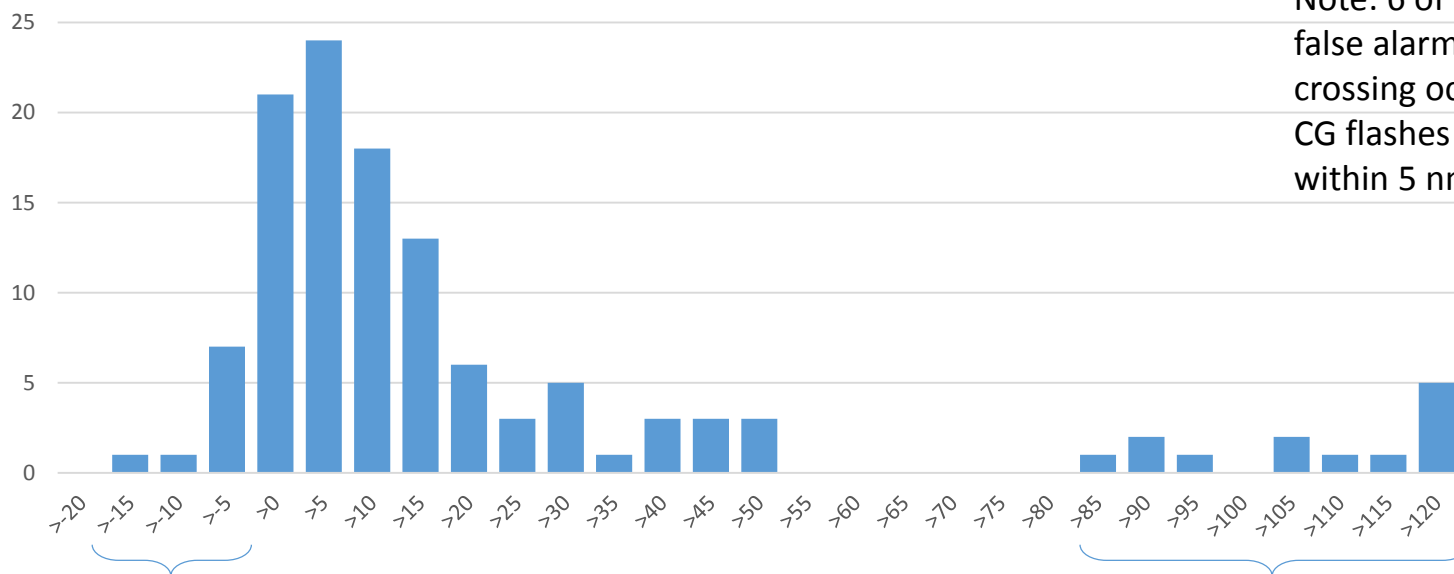


Analysis

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Time (min.) from Elec Field Zero Crossing
to 1st CG within 5 nm



Note: 6 of the 128 were false alarms (i.e., zero crossing occurred but CG flashes were not within 5 nm)

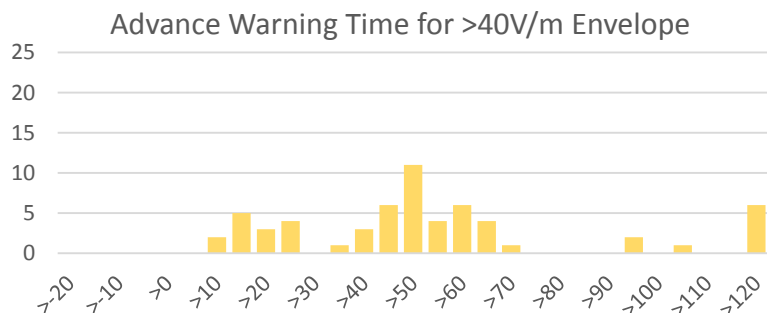
In 7 of 128 cases, CG flashes occurred within 5nm before the electric field crossed zero

First storms produced fields at field mill but CG were not within 5nm

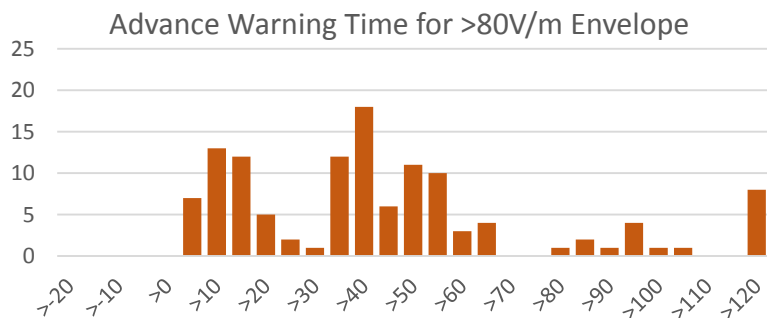
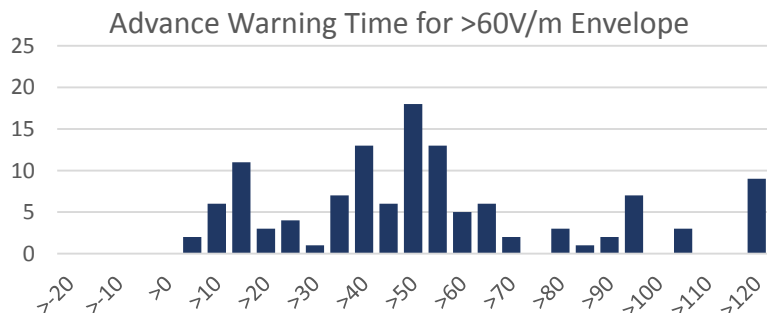


Analysis

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69 of 128 were exceeding envelope at beginning of analysis period



- 6 of the 28 (for envelope of 60 V/m or more) were false alarms (i.e., lightning was in the area but not within 5 nm)
- In all cases the envelope method preceded the 1st CG within 5nm an improvement over using zero crossing (see next chart)
- Lead times greater than an hour were associated with onset of earlier storms near the field mill but lightning was not within 5nm and later lightning storms formed over the field mill (see next chart)

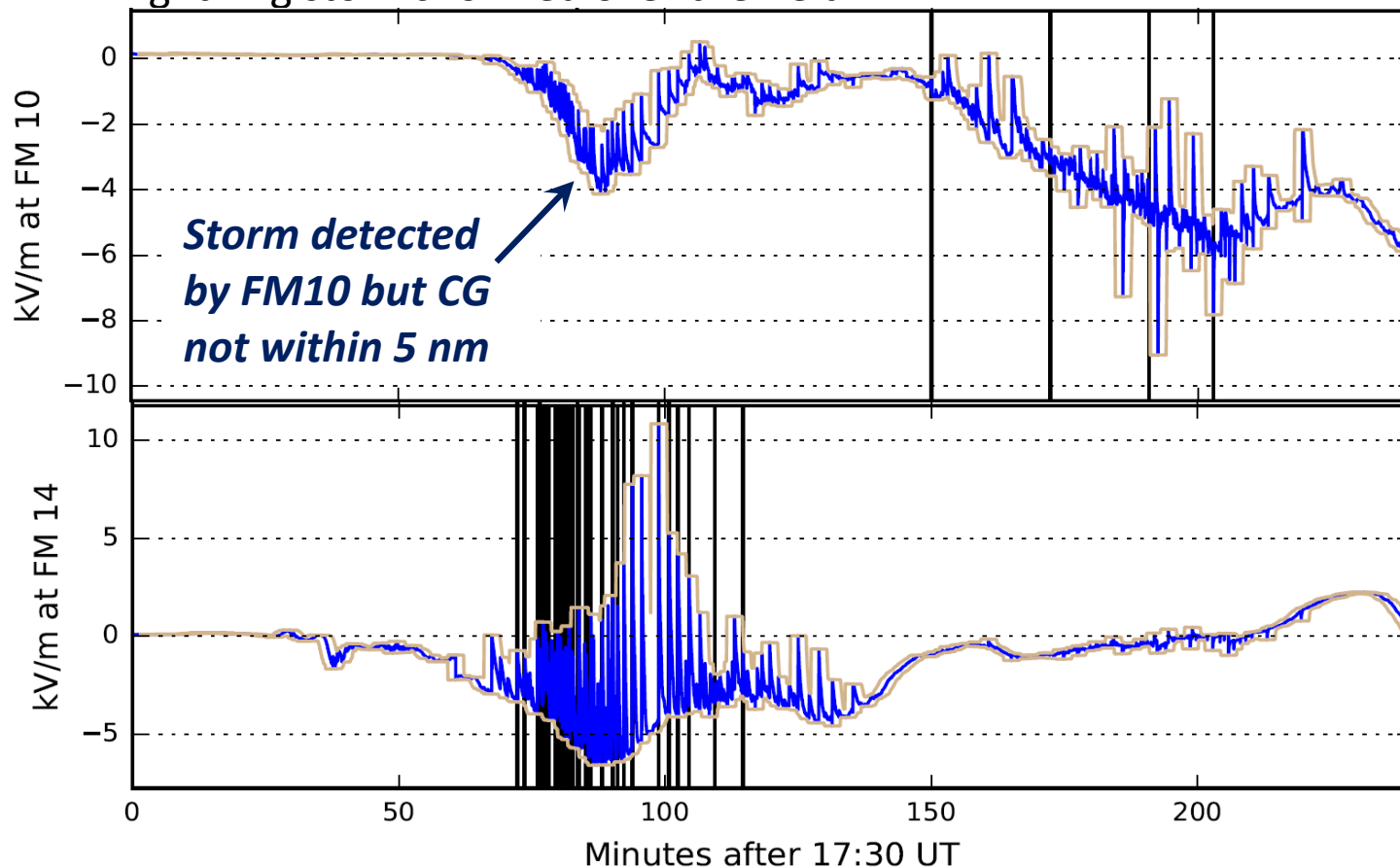


Analysis



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Lead times greater than an hour were associated with onset of earlier storms near the field mill but lightning was not within 5nm and later lightning storms formed over the field mill



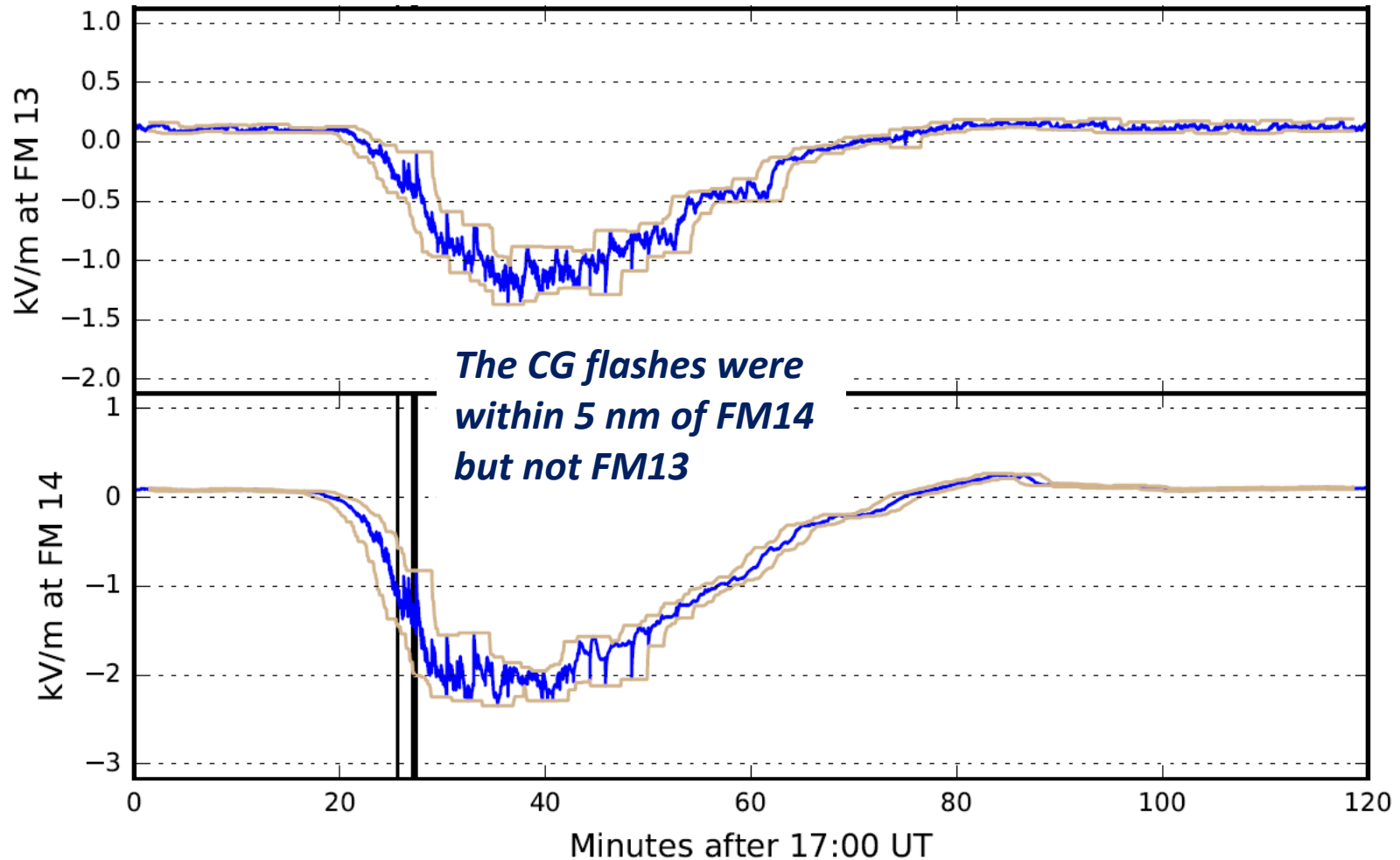


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6 of the 28 (for envelope of 60 V/m or more) were false alarms
(i.e., lightning was in the area but not within 5 nm)





Conclusion



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- Using an exceedance in the envelope of the Electric field provides greater warning than using the zero crossing
- False alarms occur when storms are nearby but the CG flashes are just outside of 5 nm
 - In this analysis 6 of 128 were false alarms
 - Using zero crossing resulted in the same false alarms
- Future work may also provide indication of end of storm using similar method



Backup

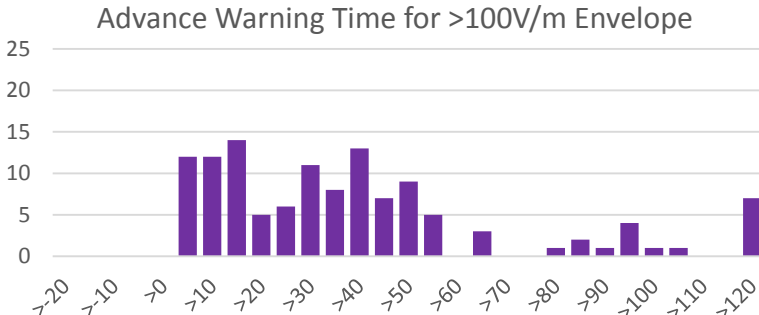
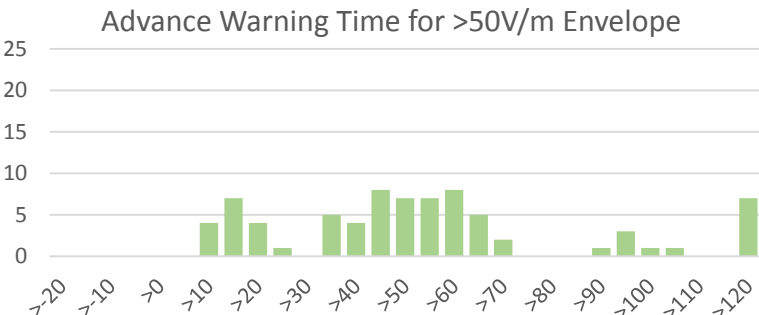
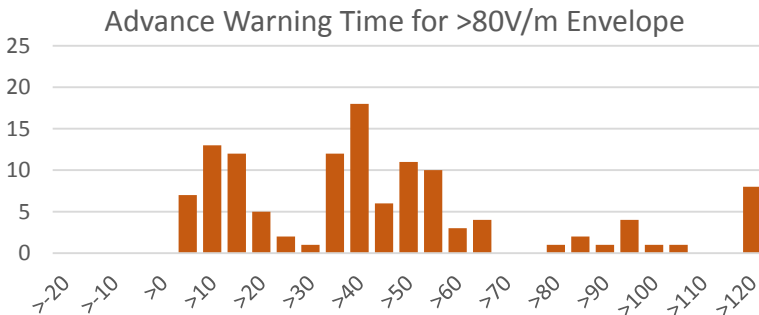
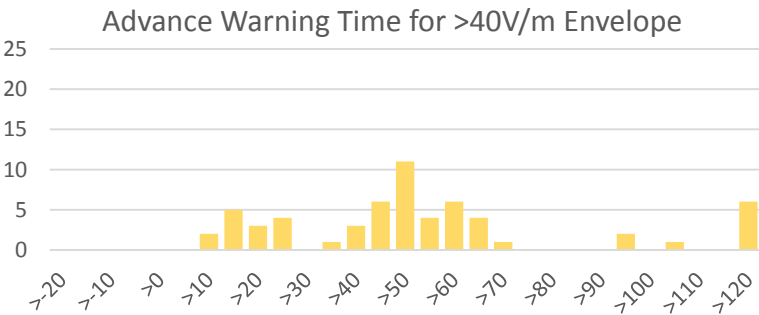
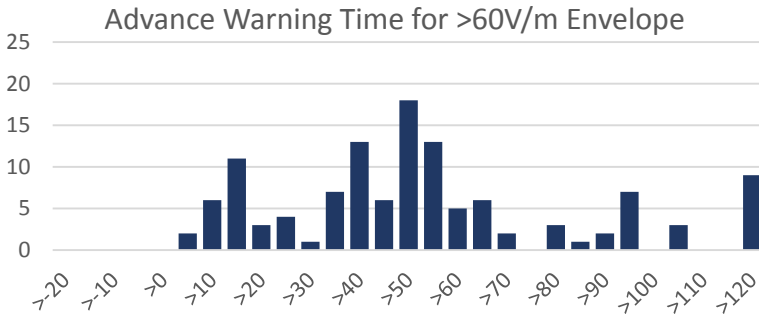
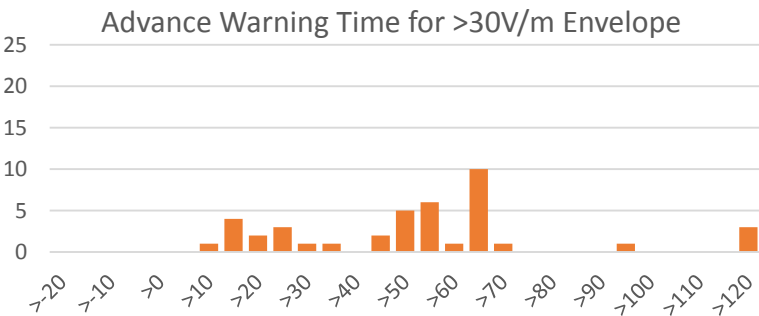


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Analysis

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Electric Field Averaging, Enveloping and Standard Deviation

- Field Mill Data Unfiltered
 - Upper Envelope
 - Lower Envelope
 - Average
 - Standard Deviation
- Vertical Lines represent CG flashes

